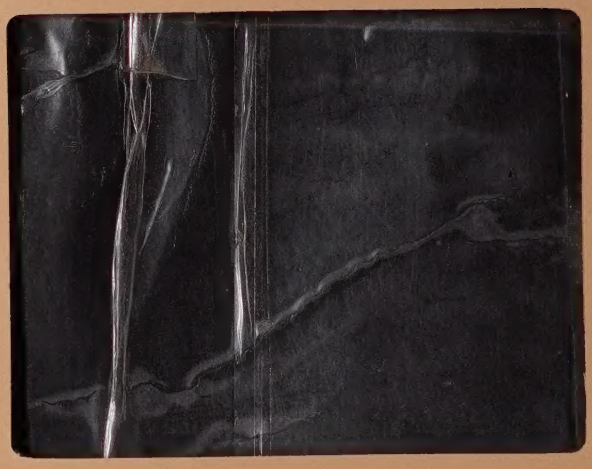
INSTRUMENT SHOP

BIRTCHER

ELECTRONICS FOR MEDICINE

the BIRTCHER CORPORATION
MEDICAL DIVISION
4371 VALLEY BLVD. • LOS ANGELES, CALIF. 90032



INSTRUMENT SHOP

SERVICE HANDBOOK
PARTS CATALOGUE

ELECTROCARDIOGRAPH

model 335-1&-2

for Santa Cruz EKG
Rec'd 6-23-70
PR M4906

the BIRTCHER CORPORATION

501-D-41

4371 VALLEY BLVD., LOS ANGELES, CALIFORNIA 90032 | (213) 222-9101

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SECTION I
GENERAL DESCRIPTION

1.1 INTRODUCTION. This manual comprises complete service instructions for the Electrocardiograph.

1.2. EQUIPMENT SUPPLIED. The accessories supplied with the Electrocardiograph are listed in the Accessory list on page 10.

1.3. SPECIFICATIONS.

Finish ..... Two-tone, infrared-cured, baked enamel.

Dimensions ..... 16 3/4 x 7 x 10 inches. Volume: 1120 cubic inches.

Weight ..... 25 pounds with all accessories.

Input Power Requirement ... 115 volts, 60 CPS (NOTE: Upon request 50 or 60 CPS models can be supplied to operate at 100, 115, 150, 200, 220 or 250 volts).

Power Consumption ... 85 watts maximum.

Grounding ..... Through third wire in the line cord or through line cord by means of polarity indicator.

Patient Circuit .... Input resistance 20 megohms each grid, differential input.

Amplification ..... Five stages of push-pull with progressive differential effect.

In Phase Rejection ..... 1500 to 1 or better.

Standardization Voltage ..... 1 millivolt DC. (derived from standard mercury cell)

Voltage Regulation ..... 1. Circuit voltages
   a. Regulation to 0.0029% with ±10% AC line voltage variance.
   b. AC ripple, 30 millivolts peak-to-peak.
2. Heater voltage for input tubes.
   a. Regulation to 0.0096% with ±10% AC line voltage variation.
   b. AC ripple, 20 millivolts peak-to-peak.

Recording Method ..... On heat-sensitive paper by heated stylus.

Total Sensitivity ..... 14 mm/mv minimum with continuous control.

Frequency Characteristic .. The recorded response to 1 millivolt peak voltage variation from 1 cycle to 15 cycles per second is greater than 90%, and from 15 to 40 cycles greater than 80%.

Base Line Positioning ..... Adjustable ±25mm progressively and without lag.

Decay Time ..... At 0.2 second, response will not deviate by more than 5%.

Linearity ..... Maximum error ±5% over ±2 cm of the recording paper from applied 1 millivolt signal with sensitivity adjusted to 1 mv/cm deflection.

Recording Speed ... 2.5 or 2.5 and 5 cm/sec.

Paper Drive ..... Synchronous motor.

Galvanometer ..... a. Sensitivity 31 to 35 ma for 1 cm deflection at 10 cm radius.
   b. Gauss 6400.
   c. Restoring force, 112,000 dyne cm.

General Operation ..... Standard Sensitivity of 1 millivolt-per-cm.

Lead selector switch with 1, 2, 3, AVR, AVL, AVF, V and 1/2V positions.

Automatic blanking between leads except V leads.

D.C. Amplifier .... Accepts push-pull or single-ended input with 4 megohms input impedance (each input terminal to ground): sensitivity approximately 30 MV per 10 mm of stylus deflection with sensitivity control at center of its rotation.

SECTION II
CIRCUIT DESCRIPTION

2.1. SCOPE. A general description is given here to acquaint the service technician with the basic functions of each major circuit. No attempt is made in this section to describe the purpose or function of every single component in this equipment. It is assumed that the service technician is familiar enough with general electronic theory to determine, from the circuit diagram, the identity and purpose of common components such as grid resistors, coupling capacitors, etc. Thus, careful study should be made of the block diagram (Fig. 1) and the circuit schematic (Fig. 10) prior to servicing the electrocardiograph.

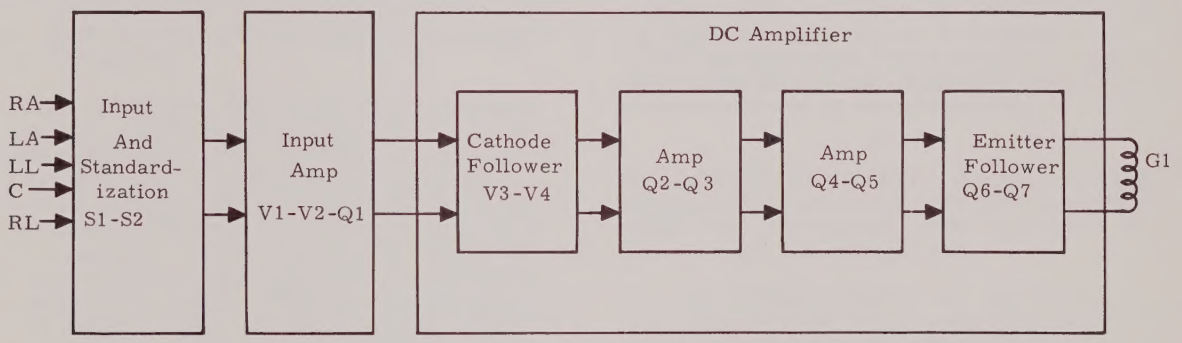


Figure 1. Block Diagram

2.2. GENERAL. The electrocardiograph consists of an input and standardization circuit, input amplifier, DC amplifier, galvanometer, paper drive, and power supply. The input and standardization circuit selects the patient leads to be recorded and provides a standard voltage for calibration of the amplifiers. The input and DC amplifiers amplify the input signal sufficiently to drive the galvanometer. The galvanometer physically moves the stylus in accordance with its input and thus in accordance with the signal supplied by the selected patient lead. The paper drive moves the recording paper, at a standardized speed, under the recording stylus. The power supply provides the power to operate the various circuits.

2.3. INPUT AND STANDARDIZATION CIRCUIT. The input circuit consists of the five-wire patient cable and associated electrodes, LEAD SELECTOR switch S1, patient terminal network resistors R1 through R7, and input network capacitors C1 and C2 and resistors R8, R9, R11 and R12. LEAD SELECTOR switch S1 establishes the proper terminal networks for the various leads. All patient electrodes are connected to the contacts of S1 through input connector J4. The LEAD SELECTOR switch selects the proper electrodes (or combinations thereof) for connection to input amplifier V1-V2. RF bypass capacitors C1 and C2 eliminate any RF interference present. The use of an electron tube (Nuvistor) input amplifier provides a high input impedance. Battery B1 provides the standardization voltage for calibration of the amplifiers. When STANDARDIZING 1 MILLIVOLT switch S2 is pressed, a 1 MV voltage is introduced into the input of the amplifier. With LEAD SELECTOR switch S1 in the STD position the standardizing voltage is supplied directly to the input through resistors R11 and R12. With LEAD SELECTOR switch S1 in any of the eight operating positions the voltage is supplied through the patient circuit to the grid of V2. This circuit wiring allows the operator to enter a standardization pulse during a recording, by pressing S2, without the necessity to return LEAD SELECTOR switch S1 to STD.

2.4. INPUT AMPLIFIER. The input amplifier V1-V2 consists of two Nuvistor triodes connected as a differential amplifier. An electron tube circuit is used to maintain a high input impedance. Use of a differential amplifier allows a high amplification while minimizing the effects of in-phase interference signals, hum, power voltage variations, etc. Microphonics are minimized by using rubber shock mounts for the entire amplifier assembly. A regulated DC voltage filament supply is utilized to prevent heater-

to-cathode leakage and heater power variations. A regulated filament supply ensures stable operation for line voltage variations of 105 to 130 volts. Transistor Q1 functions as a constant current regulator to maintain a constant current source to the cathode circuits, thus improving the natural in-phase rejection capability of the differential amplifier. The AC impedance, looking from the cathodes through the collector-emitter junction of Q1 is high, however, the DC resistance in the opposite direction is low. Thus, the in-phase rejection capabilities of the differential amplifier is improved without a large cathode resistor and negative supply voltage. The amplified signals are capacitively coupled through C3 and C6 to the inputs of the DC amplifier. Control R14 is used to improve the dynamic balance of V1 and V2.

2.5. DC AMPLIFIER. The DC amplifier consists of Nuvistor cathode-follower V3-V4, transistor amplifiers Q2-Q3 and Q4-Q5, and emitter-follower Q6-Q7. As in the input amplifier these stages are operated in push-pull.

2.5.1. CATHODE FOLLOWER V3-V4. The outputs of the input amplifier are fed to the grids of cathode-follower V3-V4. This circuit is employed in order to convert the high impedance output of the input amplifier to a low impedance input to the transistor amplifiers. The dynamic balance of V3-V4 is controlled by potentiometer R25. Sensitivity is controlled by potentiometer R29. This control is connected in series with R30 between the cathodes of V3 and V4. Since the cathode signals are 180° out of phase the effect of the SENSITIVITY control is to cause partial cancellation, thus attenuation, of the signals. Minimum attenuation (maximum sensitivity) is provided with SENSITIVITY control set to maximum resistance (fully CW). Maximum attenuation (minimum sensitivity) is provided with SENSITIVITY control set to minimum resistance (fully CCW). This control enables the operator to calibrate the sensitivity of the ECG for proper stylus deflection during application of the 1 MV standardizing voltage. Compensation, therefore, can be made for gradual changes in ECG sensitivity.

2.5.2. AMPLIFIERS Q2-Q3 and Q4-Q5. Amplifiers Q2-Q3 and Q4-Q5 are conventional push-pull common emitter amplifiers. In addition to the conventional circuitry, potentiometer R33 is provided in the emitter circuits of Q2 and Q3 to allow centering of the writing stylus. This control is somewhat analogous to the BALANCE control R25 in the input amplifier. The arm of the CENTERING control is connected to the emitter power source. This control can be adjusted to provide more or less resistance to either stage and thus increase or decrease their current flow. The current flow would be altered in the succeeding stages and thus displaces the writing stylus. Thus, compensation for normal unbalanced conditions of the amplifier are made by adjustment of the CENTERING control.

2.5.3. EMITTER-FOLLOWER Q6-Q7. Emitter-follower Q6-Q7 provides the current to drive galvanometer G1. An emitter-follower circuit is used in order to provide a low impedance driving source. The low impedance output improves the electrical damping characteristics of the galvanometer. Negative feed back is provided to the emitters of stage Q2-Q3 through FREQ-ADJ control R38-R41. This negative feedback promotes stability and lowers the effective output impedance of Q6-Q7.

2.6. GALVANOMETER G1. The galvanometer rereceives the cardiac signals from emitter-follower Q6-Q7 and positions the writing stylus accordingly. The FREQ-ADJ control R38-R41 and capacitor C11 constitute a tuned RC circuit. This circuit reduces the negative feedback at frequencies above 30 CPS. Thus, by adding the proper amount of resistance, the frequency response slope can be adjusted to compensate for the natural loss of gain for higher frequencies, experienced by the galvanometer.

2.7. CHART DOOR LIGHT. The chart door light serves as a fuse and power limiter for the collectors of Q6 & Q7. The intensity of the chart door light will vary with the setting of R33.

2.8. AC INTERFERENCE. AC interference is the most common form of interference due to the widespread use of flourescent lighting and other electronic equipment operating from the 115-volt power line. Figure 4 illustrates an example of AC interference. The in-phase rejection characteristics of the input amplifier will cancel normal amounts of in-phase interference. However, all possible steps should be taken to eliminate interference at its source or operating in an area relatively free from interference. In addition, it is essential that the ECG is properly grounded. When KE1-1, cord adapter is used the polarity lamp DS1 should be extinguished when ECG is properly grounded. Polarity lamp DS1 is extinguished when the ECG is properly grounded. If the polarity lamp glows when S3 is touched, set POLARITY REVERSE switch S3 to the opposite position. In cases of severe interference it may be necessary to make a direct ground to a water pipe or radiator. A patient too near AC power lines can produce excessive interference.

2.9. POWER SUPPLY. The power supply provides regulated power at the various voltages required by the ECG. The regulation is conventional, utilizing a zener diode CR3 as a reference voltage, amplifier V5B and series regulator V5A.

SECTION III
MAINTENANCE

3.1. GENERAL. This manual covers only the basic material to maintain the ECG in proper working order. Figure 10 is the schematic diagram, Table 1 lists pertinent voltage measurements and paragraphs 3.3 through 3.5 list alignment and troubleshooting procedures. In the course of normal operation the ECG requires certain routine maintenance of the type that can be performed by operating personnel who are thoroughly familiar with the operating characteristics of the instrument but who may not understand all of its technical aspects. Maintenance of this type includes the following:

a. Replacement of indicator lamps.
b. Replacement of power fuse.
c. Repair or replacement of writing or marking stylii; adjustment of stylus pressure.
d. Replacement of recording paper and cleaning of paper guide bar.
e. Cleaning of electrodes.

Operating personnel, therefore, should know how to perform the above maintenance, and should be able to recognize the symptoms that indicate that maintenance is required. All other maintenance should be performed by competent factory-recognized technicians who have a thorough understanding of the equipment. Since most symptoms of trouble are clearly indicated by deviations from the characteristics exhibited by test tapes, it is essential that both operating and maintenance personnel be well acquainted with these characteristics in order to recognize possible equipment malfunctions. Before taking any corrective action ensure that the trouble is in the equipment, and is not caused by such things as improper operating techniques, defective cables, an incorrect power source, poor ground connections, or excessive local interference. In addition, before performing any maintenance thoroughly read the maintenance section paying special attention to paragraphs pertaining to precautions. Do not make any calibration or adjustments until it is determined that any and all circuit malfunctions have been found and corrected.

3.2. CHECKS AND ALIGNMENT.

3.2.1. PRELIMINARY ELECTRICAL SET-UP. The transistors used in the D.C. amplifier must have matched D.C. parameters within 5%.

3.2.2. POWER SUPPLY. Voltage measurements on amplifier board. (±20%)

A. Pin 11 to ground = +19V
B. Pin 28 to ground = +175V
C. Pin 26 to ground = -6V
D. Measure the A.C. voltage at the stylus terminals on the galvanometer with the stylus temperature maximum and paper drive motor running, minimum 1.75 volts.

3.2.3. D.C. AMPLIFIER BALANCE WITH LEAD SELECTOR SWITCH IN BLANK POSITION.

A. Attach a clip lead between pin 8 of V3 and pin 8 of V4.
B. Center stylus with centering control (R33).
C. Set sensitivity control (R29) maximum clockwise.
D. Remove clip lead in step A.
E. Center stylus with D.C. balance adjust (R25).
F. Change nuvistors V3 or V4 if above step cannot be achieved.

3.2.4. STANDARDIZATION CHECK.

A. Standardize E.C.G. using an external 1 millivolt standard pulse.
B. Standard pulse from E.C.G. should be a maximum of ± .2 mm of that obtained in step A.

3.2.5. FREQUENCY RESPONSE ADJUSTMENT.

A. Adjust stylus temperature control to maximum, input line voltage at 115 volts.
B. Adjust stylus to just touch the paper that is being drawn across the writing bar. If the stylus has a flat area, rotate until the flat area is in full contact with the paper.
C. Re-adjust stylus temperature to normal, approximately mid-range.
D. With E.C.G. standardized, inject a 1 millivolt peak to peak 40 cycle sine wave and adjust frequency control until a minimum of 80% response (8mm) is obtained.
E. Adjust stylus pressure to obtain a clean 40 cycle trace. Refer to Figure 2 for location of stylus pressure adjusting screws.
F. Repeat step D.

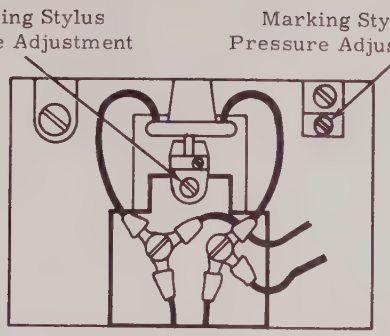


Fig. 2. Stylus Pressure Adjustment

G. Check square wave and increase frequency response if necessary to obtain "flat" top on square wave as per Figure 3A. Turn frequency control clockwise to increase frequency response.

Figure 3.

1. Figure 3B is over damped, cause:
   a. Frequency response at 40 cycles too low.
   b. Stylus pressure too excessive.
2. Figure 3C under damped, cause:
   a. Frequency response at 40 cycles too high.
   b. Stylus pressure not great enough.

3.2.6. DECAY TIME CHECK (LOW FREQUENCY RESPONSE)

A. With ECG standardized for 1 cm., inject standard pulse - hold for a period of .5 second.
B. Deviation of amplitude of square wave shall not be greater than 10% (1mm) after .2 second.

3.2.7. INPHASE REJECTION.

A. With ECG standardized for 1 cm., inject a 1 volt, 10 cycle signal into both grids. RA and LA (lead one).
B. Check for a minimum of 1500 to 1 rejection (6mm).
C. Adjust inphase rejection control for minimum deflection (maximum inphase rejection). NOTE: Turn lead selector to blank position when making adjustments.
D. Change V1 to V2 if minimum of 1500-1 inphase rejection cannot be obtained.

3.2.8. LINEARITY AND OVERSHOOT TEST.

A. With ECG standardized for 1 cm., check square wave response at 2 cm on each side of center line for over-shoot and linearity.
B. Linearity must be within a maximum of 5% of 1 cm. (.5 mm).
C. Over-shoot must be within a maximum of 2% of 1 cm. (.2mm)

3.2.9. MINIMUM GAIN CHECK.

A. Adjust sensitivity control for maximum gain and check amplitude of square wave.
B. Amplitude of square wave shall be a minimum of 14 mm.
C. Change V1 and/or V2 if minimum gain cannot be achieved.
D. A change of 1 mm in amplitude may be obtained by changing Q1.
E. Adjust sensitivity control for minimum gain, must be under 1/2 cm.

3.2.10. BASE LINE STABILITY AND 60 CYCLE HUM CHECK.

A. With ECG thoroughly warmed up and standardized for 1 cm., base line wander shall be a maximum of $\pm$ 1 mm.
B. Base line shall be clear of 60 cycle hum.

3.2.11. INPUT BALANCE TEST.

A. Standardize unit, 1 cm deflection.
B. Inject a 40 millivolt D.C. voltage into lead one, RA and LA with respect to ground, and check standardization, reverse the polarity of the 40 millivolt signal and check standardization.
   1. No deviation is allowed.
   2. If deviation occurs check:
      a. Paragraph 3.2.7 inphase rejection.
      b. Change V1, V2, & Q1.
      c. Check power supply voltage.

3.2.12. AGING AND FINAL CHECK.

A. ECG's shall be operated continuously in the "on" position with the lead selector in the standard position for a period of not less than 12 hours.
   1. After unit has been operating a minimum of one hour on the line repeat step 3.2.3.
B. After aging, the following checks will be made:
   1. Base line stability.
   2. Frequency response.
   3. Heart trace in all positions of lead selector switch.
   4. Tension of paper drag and proper feeding of paper.
   5. D.C. balance shall be within $\pm$ 3 mm.

3.3. VOLTAGE MEASUREMENTS. Table 1 lists typical indication of voltage measurements. Thoroughly read the notes in Table 1 and duplicate the conditions prior to taking measurements. One measurement is taken with the negative probe grounded, and the second measurement taken with the positive probe grounded. The difference occurs due to the semiconductors in the circuits. Although measurements will vary with different ECG's and VTVM's the technician should note a similarity in the pattern of measurements. Any noted deviation may indicate a defect in that particular circuit.

TABLE 1. VOLTAGE CHART

NOTES:
1. All measurements are from pin to chassis ground.
2. Measurements are subject to variations due to accuracy of meters used and tolerance of circuit components.
3. All measurements taken with a VTVM.
4. All voltage measurements made with 115 VAC power source, LEAD SELECTOR set to STD, and OFF-ON-2.5-5.0 switch set to ON.
5. Tube and transistors pin voltages ±10%.

ELECTRON TUBES AND TRANSISTORS

PIN NO.	VOLTAGE	PIN NO.	VOLTAGES	PIN NO.	VOLTAGES	PIN NO.	VOLTAGES
V1-2	*100	V2-2	*100	V3-2	140	V4-2	140
V1-4	0	V2-4	0	V3-4	0	V4-4	0
V1-8	1.2	V2-8	1.3	V3-8	2.25	V4-8	2.25
V1-10	0	V2-10	0	V3-10	11.8	V4-10	11.8
V1-12	5.8	V2-12	-5.8	V3-12	5.8	V4-12	17
V5-1	350						
V5-2	172						
V5-3	175						
V5-6	172						
V5-7	85						
V5-8	85						
V5-9	85						
Q1-C	1	Q2-C	-1.25	Q3-C	-1.25	Q4-C	8.3
Q1-B	.35	Q2-B	2.25	Q3-B	2.25	Q4-B	-1.25
Q1-E	.05	Q2-E	2.4	Q3-E	2.4	Q4-E	-1.4
Q5-C	8.3	Q6-C	-23	Q7-C	-23	Q8-C	-27
Q5-B	-1.25	Q6-B	8.3	Q7-B	8.3	Q8-B	-6
Q5-E	-1.4	Q6-E	8.4	Q7-E	8.4	Q8-E	-5.9
Q9-C	-27						
Q9-B	-5.8						
Q9-E	-5.7						

* ± 20% will vary with the setting of R14

B+	(Pin 1 of V5 unregulated)	: 350V
B-		: -6V
B+	(Pin 28)	: 175V
	(Pin 26)	: -6V
	(Pin 11)	: +19V

3.4 TEST RECORDINGS. Test recordings should be made as follows:

TRACE I

a. With LEAD SELECTOR switch in STD position, begin recording and enter standardization pulse properly adjusted to 1.0 CM deflection (10 small spaces).

b. Without changing sensitivity, adjust CENTERING so stylus is 1.0 CM above normal centerline. Produce a standardization pulse.

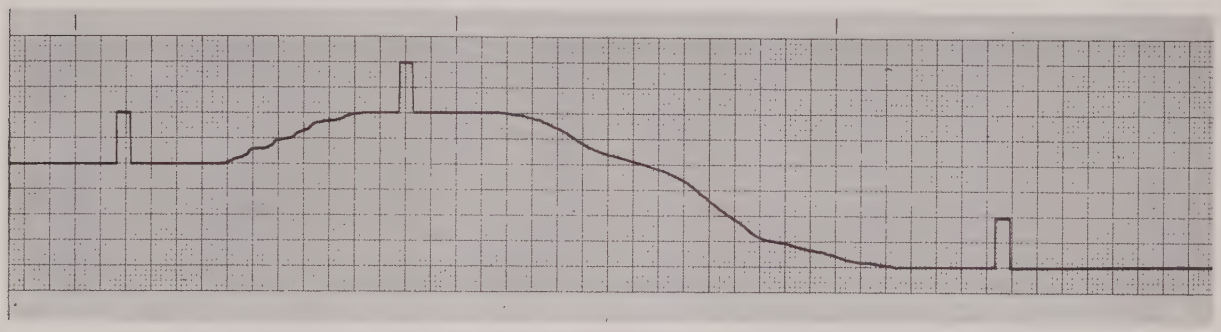
c. Adjust CENTERING so that stylus is 2.0 CM below normal centerline. Produce a standardization pulse. Return stylus to mid-position with CENTERING adjustment. The trace should be similar to the one illustrated on page 7. Any deviation may indicate a malfunction.

TRACE II

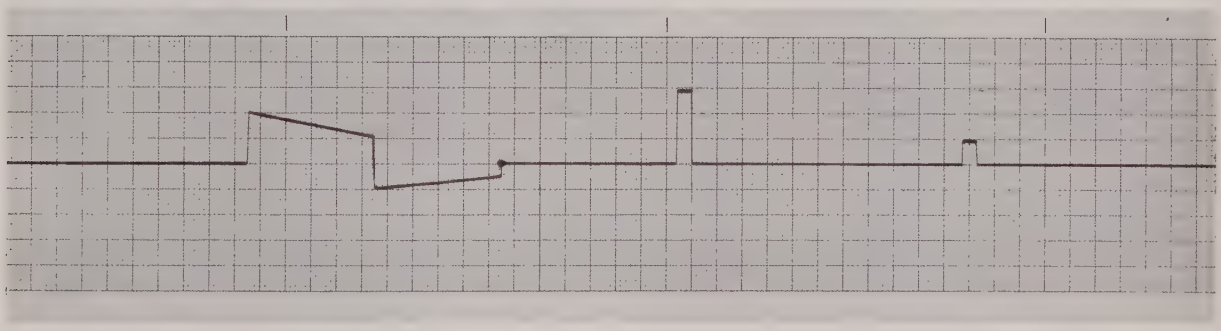
a. With sensitivity remaining as above, depress 1-MILLIVOLT STANDARD button and hold depressed for one second. Release button and continue paper drive for about one second before stopping.

b. Turn SENSITIVITY control fully clockwise. Set OFF-ON-2.5-5.0 switch to 2.5 to start paper drive and produce a pulse with the 1-MILLIVOLT STANDARD button. Set OFF-ON-2.5-5.0 switch to ON to stop paper drive.

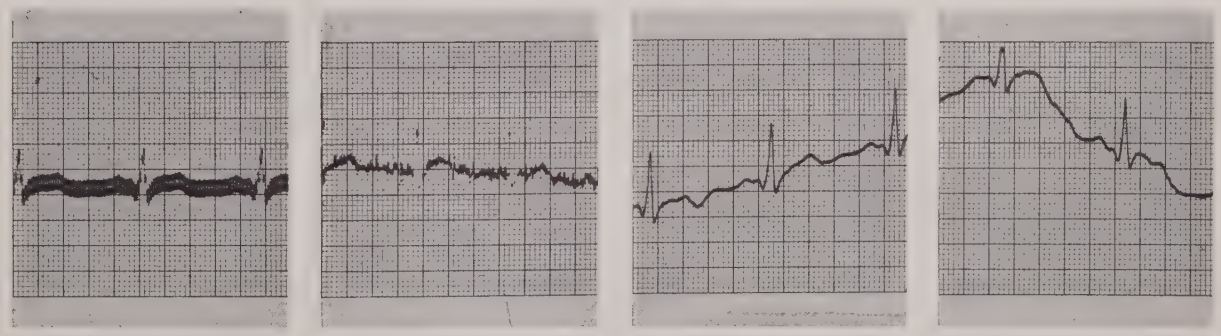
c. Adjust SENSITIVITY control to proper level and produce a 1/2 standardization pulse (vertical deflection of 0.5). The trace should be similar to the one illustrated in trace II. Any deviation may indicate a malfunction. Figure 4 illustrates examples of test recordings of abnormal trace characteristics.



Trace I



Trace II



A.C. Interference | Muscle Tremor | Movement of Patient | Poor Electrode Contact

Figure 4

IMPORTANT: In addition to the "Service information Tapes" always - if possible have technician furnish you with a tracing resulting from the electrocardiograph believed to require service. This action will result in more rapid analysis and of difficulties that may be encountered.

TABLE 2. TROUBLE SHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
ECG completely inoperative; indicator lamp in paper compartment not illuminated, paper drive motor does not operate.	Fuse F1 blown.	Replace fuse. If fuse blows again, investigate transformer T1 and power circuits for short circuit.
	Power cable defective or not properly connected.	Check connections; test cable for continuity with ohmmeter.
	Power switch S4 defective.	Replace S4.
Paper drive motor operates but no trace appears.	Stylii not heating.	Check T1. Check S4. Check R55.
	Stylus open.	Replace stylus.
ECG test recording has base line only, no standardization pulse; CENTERING control has no effect (causes no displacement of stylus), paper drive motor functions normally.	Defective power supply.	Check voltage and resistance data (table 1) for terminals 1, 4, 5, 9, 10, 17, and 26; and Q8, Q9, Q10, and Q11.
	DS4 chart lamp.	Replace DS4.
Same as preceding symptom except CENTERING control has normal effect.	Q1 defective; check J1, K1, and S1.	Replace Q1. Replace faulty part. Improper operation of BLANK and RECORD lamps indicate defective S1 or T1.
Standardization pulse has low amplitude with SENSITIVITY control at maximum; CENTERING control does not produce normal stylus displacement, but stylus can be centered properly; stylus does not deflect violently when switching leads.	One or more amplifier tubes or transistors weak.	Check by replacement method, using set known to be good.
AC interference appears on trace in standardizing position.	V1 or V2 defective.	Replace V1 or V2.
	Check C13.	Replace C13.
	Q1 defective.	Replace Q1.
	S1 defective.	Replace S1.
	V5 defective.	Replace V5.
	Line polarity incorrect.	Reverse power plug.
Intermittent operation accompanied by occasional violent deflections of stylus and possibly AC interference on same leads.	Broken wire in patient cable.	Check cable.
	If condition also occurs with LEAD SELECTOR switch in STD position.	
	Defective tube or transistor.	Check by substitution.
	Defective galvanometer coil.	Replace galvanometer.

SYMPTOM	PROBABLE CAUSE	REMEDY
Trace made by writing and/or marking stylus appears weak and is not sharply defined; STYLUS TEMP. may require excessive CW rotation.	Either stylus may be bent, may have insufficient pressure, may be coated with wax, or may be worn out. Check S4.	Repair stylus, burn off wax coating, readjust pressure, or replace as required (par 3.5). Replace S4.
Paper does not feed evenly.	Paper tension too loose; paper guide bar not properly adjusted.	Adjust paper tension and/or guide bar. (see Figure 6).
Writing stylus deflects to maximum position above or below center when ECG is turned on; CENTERING control has no effect.	V3 or V4 defective. Q2, Q3, Q4, or Q5 defective. Capacitor C3, C4, C5 or C6. Galvanometer coil open, or one-half shorted to ground. CENTERING control R33 defective. DC amplifier circuit defective.	Replace defective tube. Replace defective transistor. Replace defective capacitor. Check with ohmmeter and replace galvanometer. Replace R33. Check voltage measurements. (par 3.3) and replace defective component.
Fuse F1 blows when OFF-ON-2.5-5.0 switch is set to ON.	Transformer T1 shorted. Capacitor C14 or C15 shorted. Diode CR1, 2, 5, 6, 7, 8, shorted.	Replace T1. Replace C14 or C15. Replace defective diode.
Fuse F1 blows when OFF-ON-2.5-5.0 switch is set to 2.5 or 5.0	Paper Drive motor B1 or motor capacitor C16 defective. Defective stylus.	Replace defective component. Replace stylus.
Standardization pulse not present, otherwise operation is normal.	One-millivolt standardization circuit not functioning.	Check with voltmeter and replace defective component.
Base line wanders; somatic tremor may or may not be present.	Patient moving, ill-at-ease.	Relax patient; make certain electrodes are not too tight.

3.5. CLEANING AND REPLACEMENT OF STYLII. The stylii may become caked with wax from the recording paper after prolonged use. This causes a loss of trace definition. If the stylii appear to be coated with a wax residue, open paper loading assembly to clear stylii from paper, set OFF-ON-2.5-5.0 switch to 2.5 and turn STYLUS TEMP. to maximum for a period until wax residue burns off. If trace definition is not restored, make certain stylus pressures are adequate and stylii are making good contact with the paper before replacing either stylus. To change either stylus refer to Figure 2.

3.6. REPLACEMENT OF COMPONENTS. The high performance standards of the ECG depend on the circuit construction, accuracy and the voltage and temperature stability of its electrical parts. Careful servicing techniques will maintain this performance. If the instrument fails, the exact cause of failure should be determined before replacing parts. When replacing parts, use exact duplicates and by the same manufacturer. Since the tubes and transistors are used in differential amplifier circuits, matched pairs must be obtained and the defective tube or transistor and its counterpart must be replaced at the same time. It is recommended that these critical components be purchased from the manufacturer, where they are aged and selected for maximum performance. In addition to the critical components, aged and selected standard components may also be obtained from the manufacturer if desired. Refer to the parts list and schematic diagram for the information necessary in determining replacement parts.

SECTION IV
PARTS LIST

4.1. GENERAL. Excluding miscellaneous common hardware, all assemblies and replacement parts for the electrocardiograph are listed and illustrated in this section.

4.1.1. Major assemblies are listed and each assembly broken down to its component parts. Each assembly or part that is illustrated is referenced to the illustration by figure and index number. For example, 5 -6 in the "FIG. INDEX." column means the item is shown in figure 5 , by index number 6.

4.1.2. Reference designations on items that appear in the schematic diagram will be found in the "REF. DESIG." column of the parts list.

4.1.3. In the price column, the designation "CAT." means the item should be priced from the current Standard Catalog Price List.

4.1.4. Replacement parts should be requisitioned by part number, nomenclature and quantity described in addition to the Model and Serial number of equipment.

FIG. & INDEX NO.	PART NO.	NOMENCLATURE	REF. DESIG.	QTY.	PRICE EACH
		ACCESSORY LIST			
	243	STRAP		4	Cat.
	301S	ELECTRODE, External		4	Cat.
	302	ELECTRODE, Chest		1	Cat.
**	310F	STYLUS, Writing		1	Cat.
**	340	STYLUS, Marking		1	Cat.
	303	HOLDER		1	Cat.
	315	CABLE ASSEMBLY, Patient		1	Cat.
	320	CABLE ASSEMBLY, Power		1	Cat.
	347	PASTE		1	Cat.
**	350-N	CHART PAPER, ECG		1	Cat.
	CB8-5	DUST COVER		1	Cat.
	CB9-1	SCALE		1	Cat.
5-1	2197-1	DRUM ASSEMBLY		1	4.50
-2	BF1-9	LAMP, Incandescent #44	DS4	1	.25
-3	1937-1	WRITING BAR		1	1.50
-4	BF3-2	LAMP, Neon, NE-2	DS1	1	.75
-5	1947	DOOR WELL		1	10.00
-6*	BS1-2	FUSE, 3AG 1 AMP SLO-BLO	F1	1	.75
	BS1-10	FUSE, 3AG 1 AMP SLO-BLO 250V (Export)	F1		.75
-7	BS2-2	FUSE HOLDER		1	1.25
-8	BK1-7	SWITCH, Polarity	S3	1	2.00
-9	21807	KNOB		3	.75
-10	21601	LENS, Green		1	.75
-11*	BF1-2	LAMP, Incandescent #50	DS3	1	.10
-12*	DH7-5	NUT		2	.10
-13	BE1-12	KNOB		2	2.50
-14*	BK3-22	SWITCH, Power (335-2)	S4	1	7.50
	BK3-6	SWITCH, Power (335-1)	S4		7.50
-15	21600	LENS, Red		1	.75

*NOT SHOWN
**ONE IN UNIT

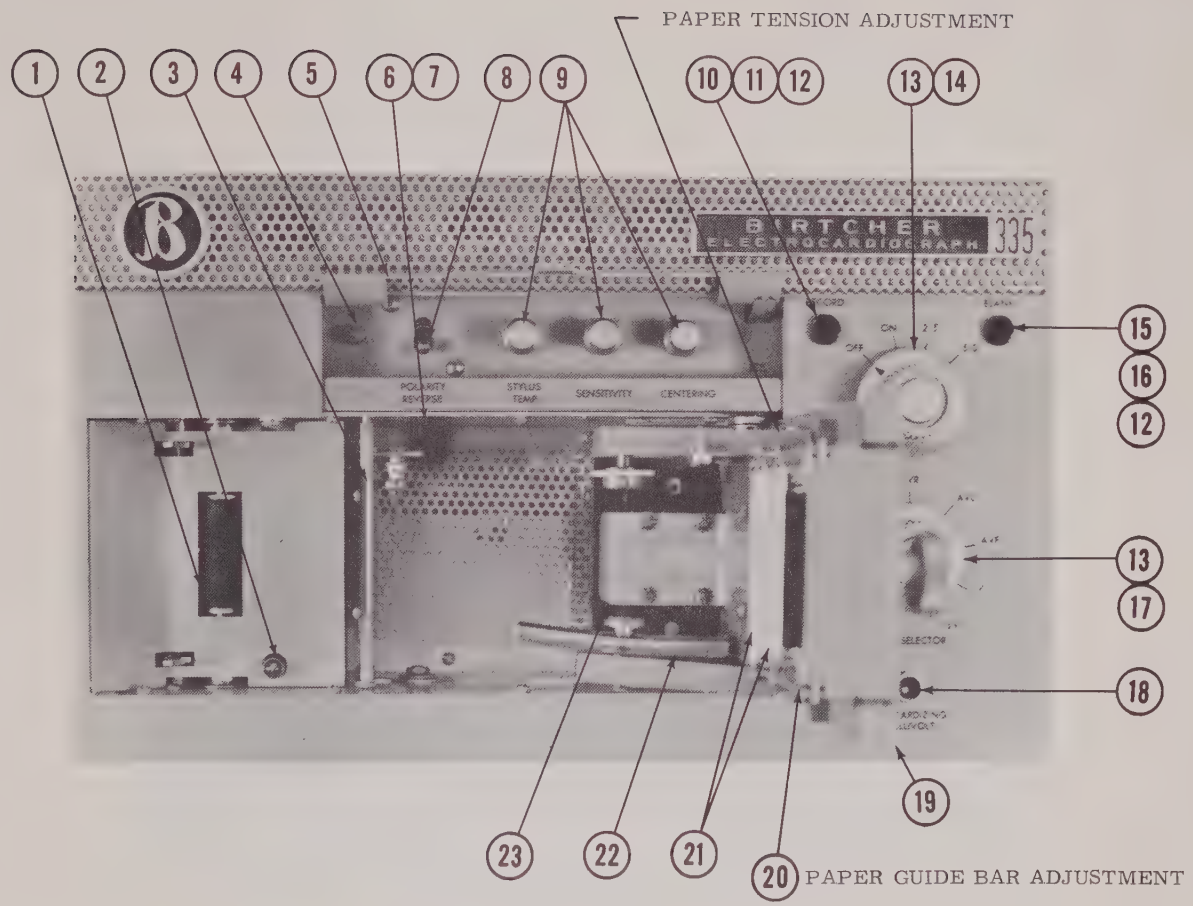


FIGURE 5. PANEL VIEW (335-2 Shown)

FIG. & INDEX NO.	PART NO.	NOMENCLATURE	REF. DESIG.	QTY.	PRICE EACH
5-16*	BF1-2	LAMP, INCANDESCENT #50	DS2	1	.10
-17	2209	SWITCH ASSEMBLY		1	55.00
-17.1*	2207	SWITCH, SELECTOR	S1	1	25.00
-17.2*	21559-1	INSULATOR PLATE		1	.35
-17.3*	21635	BOX MOUNTING		1	2.50
-17.4*	21636-1	PLATE, SIDE		1	.50
-17.5*	1943-1	BOARD ASSEMBLY		1	4.50
-17.6*	21558-1	BOARD		1	.50
-17.7*	B12-35	RESISTOR, 100 OHM 1/4 W 1%	R10	1	1.00
-17.8*	B12-36	RESISTOR, 135K 1/4 W 1%	R13	1	1.25
-17.9*	BA2-2	CELL, STANDARDIZING 1.35V	BT1	1	1.75
-17.10*	BU10-8	CONNECTOR, RECEPTACLE POWER	J3	1	1.50
-17.11*	B12-55	RESISTOR, 5.1K 1/4 W 1%	R1, 2 & 7	3	1.00
-17.12*	B12-40	RESISTOR, 3.3K 1/4 W 1%	R3	1	1.00
-17.13*	B12-23	RESISTOR, 10K 1/4 W 1%	R4, 5 & 6	3	.85
-17.14*	B11-146	RESISTOR, 20 MEG 1/2 W 5%	R8 & 9	2	.25
-17.15*	B12-2	RESISTOR, 33.2K 1/4 W 1%	R59	1	.85
-17.16*	BU1-7	CONNECTOR, RECEPTACLE	J4	1	2.50
-17.17*	22384	SHIELD		1	.50
-17.18*	21738	STIFFENER		1	1.00
-18	BK7-2	SWITCH, PUSH	S2	1	2.00

*NOT SHOWN

FIG. & INDEX NO.	PART NO.	NOMENCLATURE	REF. DESIG.	QTY.	PRICE EACH
5-19 **	1936-1	CHART DOOR ASSEMBLY		1	75.00
-19.1*	2183	LID GALVANOMETER		1	2.50
-19.2*	1976	WINDOW ASSEMBLY		1	10.00
-20	21608	ADJUSTMENT SCREW		1	.35
-21		ROLLER ASSEMBLY, PAPER GUIDE		2	1.50
-21.1*	21593-1	SHAFT		2	.15
-21.2*	21611	ROLLER ADJUSTMENT		2	.50
-21.3*	21218	BUSHING, ROLLER		4	.50
-22	1977	FRICTION CHANNEL		1	3.50
-23	1941	GALVANOMETER	G1	1	110.00

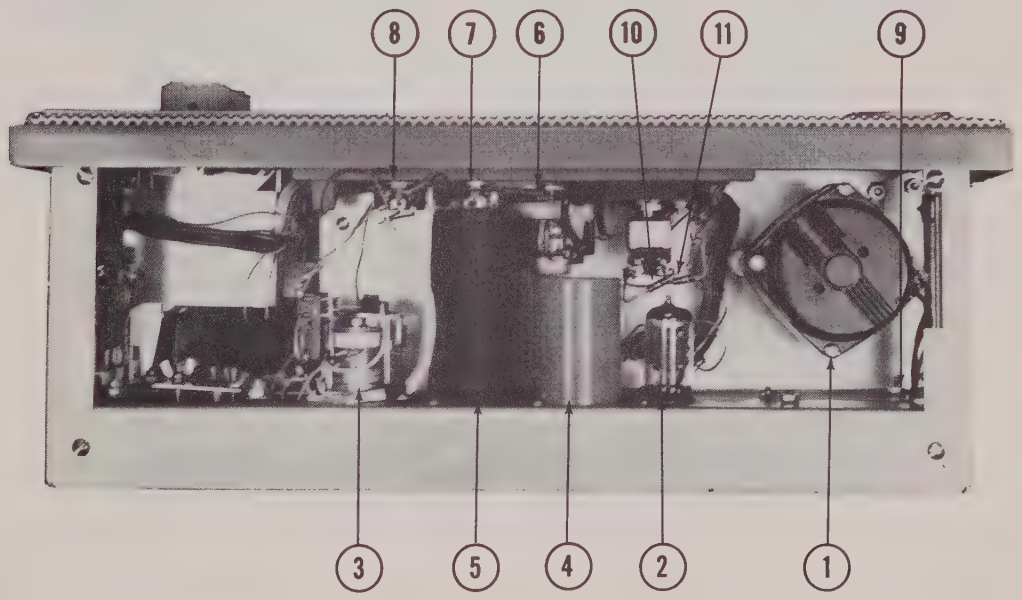


FIGURE 6. SIDE VIEW

FIG. & INDEX NO.	PART NO.	NOMENCLATURE	REF. DESIG.	QTY.	PRICE EACH
6-1	BQ-12	MOTOR, CHART DRIVE 60 cycle (335-1)	B1	1	80.00
	BQ-13	MOTOR, CHART DRIVE 50 cycle (335-1)	B1		80.00
	BQ-22	MOTOR, CHART DRIVE 60 cycle (335-2)	B1	1	95.00
	BQ-21	MOTOR, CHART DRIVE 50 cycle (335-2)	B1		95.00
-2	BL1-52	TUBE, 6AN8A	V5	1	4.00
-3	BJ1-9	RELAY	K1	1	25.00
-4	BB8-25	CAPACITOR, ELECTROLYTIC, 500 uf	C14	1	2.50
-5	BB8-22	CAPACITOR, ELECTROLYTIC, 40-40-20 uf	C12	1	4.00
-6	BI6-7	POTENTIOMETER, 1 ohm Stylus Temperature	R55	1	5.50
-7	BI6-27	POTENTIOMETER, 25K Sensitivity	R29	1	1.50
-8	BI6-28	POTENTIOMETER, 500 ohm Centering	R33	1	1.00
-9	2199	TERMINAL BOARD, MOTOR	TB1	1	1.10
-10	BI1-80	RESISTOR, 220K 1/2 W 10%	R57	1	.75
-11	BI1-69	RESISTOR, 100K 1/2 W 10%	R58	1	.20

*NOT SHOWN

** 1936-3 CHART DOOR START SERIAL NO. AU106E 3574

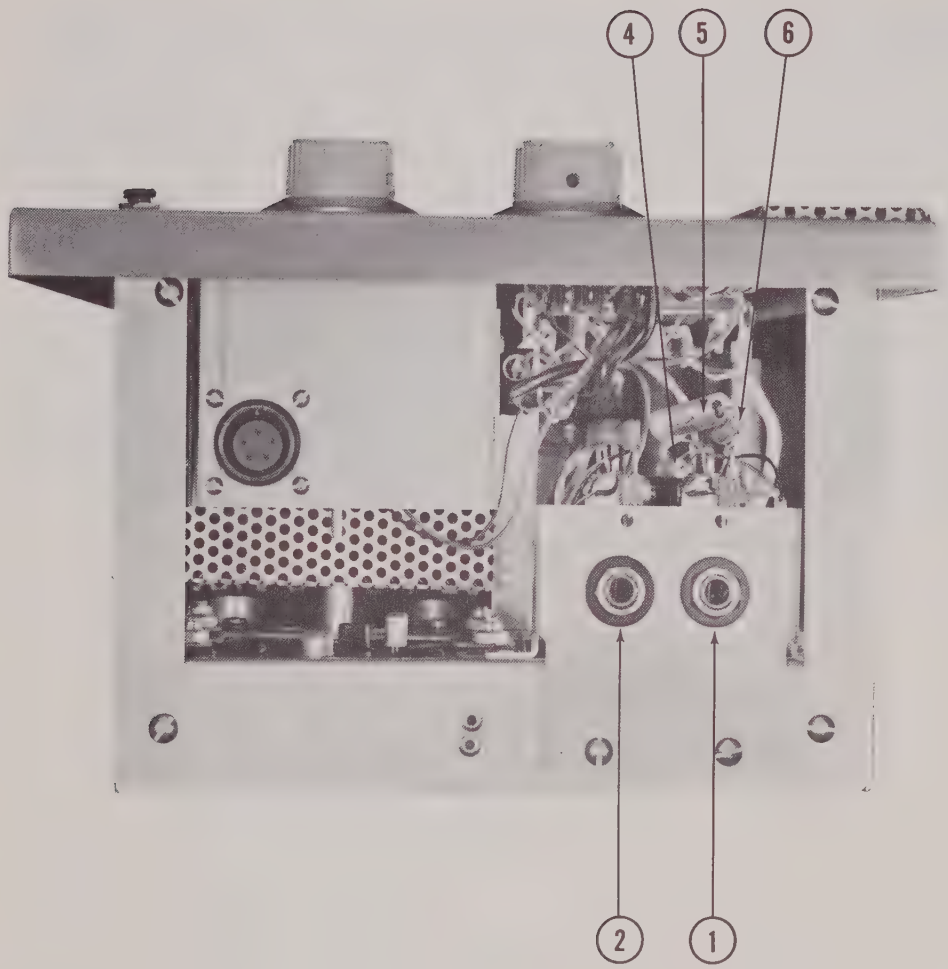


FIGURE 7. END VIEW

FIG. & INDEX NO.	PART NO.	NOMENCLATURE	REF. DESIG.	QTY.	PRICE EACH
7-1	BM3-6	CONNECTOR, Receptacle Output	J2	1	2.50
-2	BM3-6	CONNECTOR, Receptacle Input	J1	1	2.50
-3*	BB6-8	CAPACITOR, Ceramic .01 uf 600V	C17,18	2	.50
-4	BI2-2	RESISTOR, 33.2K 1/4W 1%	R46	1	.85
-5	BB10-9	CAPACITOR, Paper .082uf 100V	C10	1	3.00
-6	BI2-2	RESISTOR, 33.2K 1/4W 1%	R45	1	.85

*NOT SHOWN
C18 USED ON 335-2 ONLY

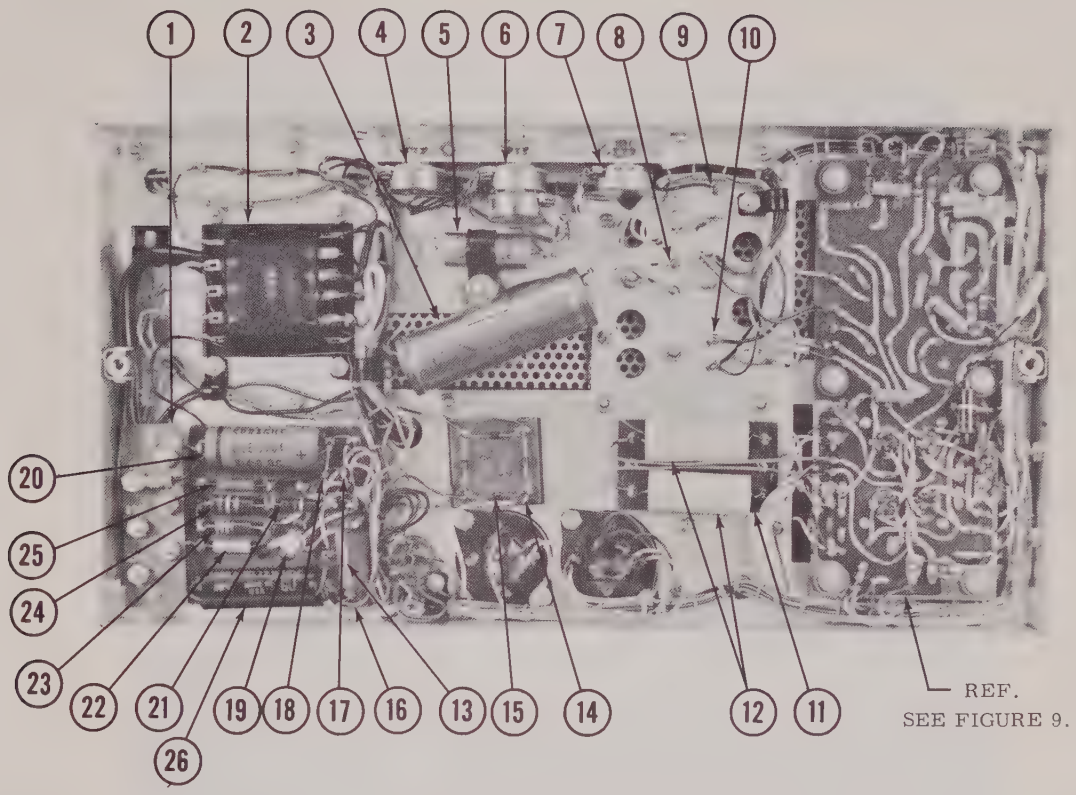


FIGURE 8. UNDER CHASSIS VIEW

FIG. & INDEX NO.	PART NO.	NOMENCLATURE	REF. DESIG.	QTY.	PRICE EACH
8-1	1802-4	TERMINAL BOARD (Export Only)	TB2	1	1.25
-2	BR1-16A	TRANSFORMER, Power 115V	T1	1	30.00
	BR5-16A	TRANSFORMER, POWER 100V to 250V (Export)	T1		35.00
-3*	BB12-1	CAPACITOR, Motor Starting 2.1 uf.220V (335-2)	C16	1	12.50
-4	B16-39	POTENTIOMETER 25K	R25	1	2.00
-5	BB10-7	CAPACITOR Electrolytic 2uf	C11	1	4.50
-6	B16-40	POTENTIOMETER Dual 10K Freq. Resp. Adj.	R38 & R41	1	3.00
-7	B16-25	POTENTIOMETER 200 Ohm 1/2W In-phase Rej.	R14	1	1.50
-8	BL4-11	TRANSISTOR 2N2869	Q 9	1	7.50
-9	BL4-11	TRANSISTOR 2N2869	Q 7	1	7.50
-10	BL4-11	TRANSISTOR 2N2869	Q 6	1	7.50
-11	2206	BOARD ASSY. Capacitor		1	5.00
-12	BB9-9	CAPACITOR, Mylar .47uf 400V	C3 & C6	2	2.00
-13	B15-4	RESISTOR 3 Ohm Wire Wound	R56	1	1.50
-14	1978	BOARD, RECTIFIER		1	2.50
-15	BL2-13	DIODE	CR5, 6, 7 & 8	4	2.00
-16	2205	BOARD Assembly		1	25.00
-17	BL2-13	DIODE	CR1	1	2.00
-18	BL2-13	DIODE	CR2	1	2.00
-19	BL4-28	TRANSISTOR 2N398A	Q 8	1	4.50
-20	BB8-31	CAPACITOR, Electrolytic 8uf 450V	C15	1	2.00
-21	BI3 -9	RESISTOR 220 Ohm 1W	R54	1	.25
-22	BI2-5	RESISTOR 5.62K 1/4W 1%	R48	1	1.00
-23	BI3-22	RESISTOR 33K 1W	R47	1	.35
-24	BI4-12	RESISTOR 27K 2W	R52	1	.75
-25	BI2-65	RESISTOR 2.21 Meg 1/4 W 1%	R53	1	1.00
-26	BB8-10	CAPACITOR, Electrolytic 100uf	C13	1	3.00

*For 335-1, C16 CAPACITOR 1.2 uf 220V supplied with B1 Motor

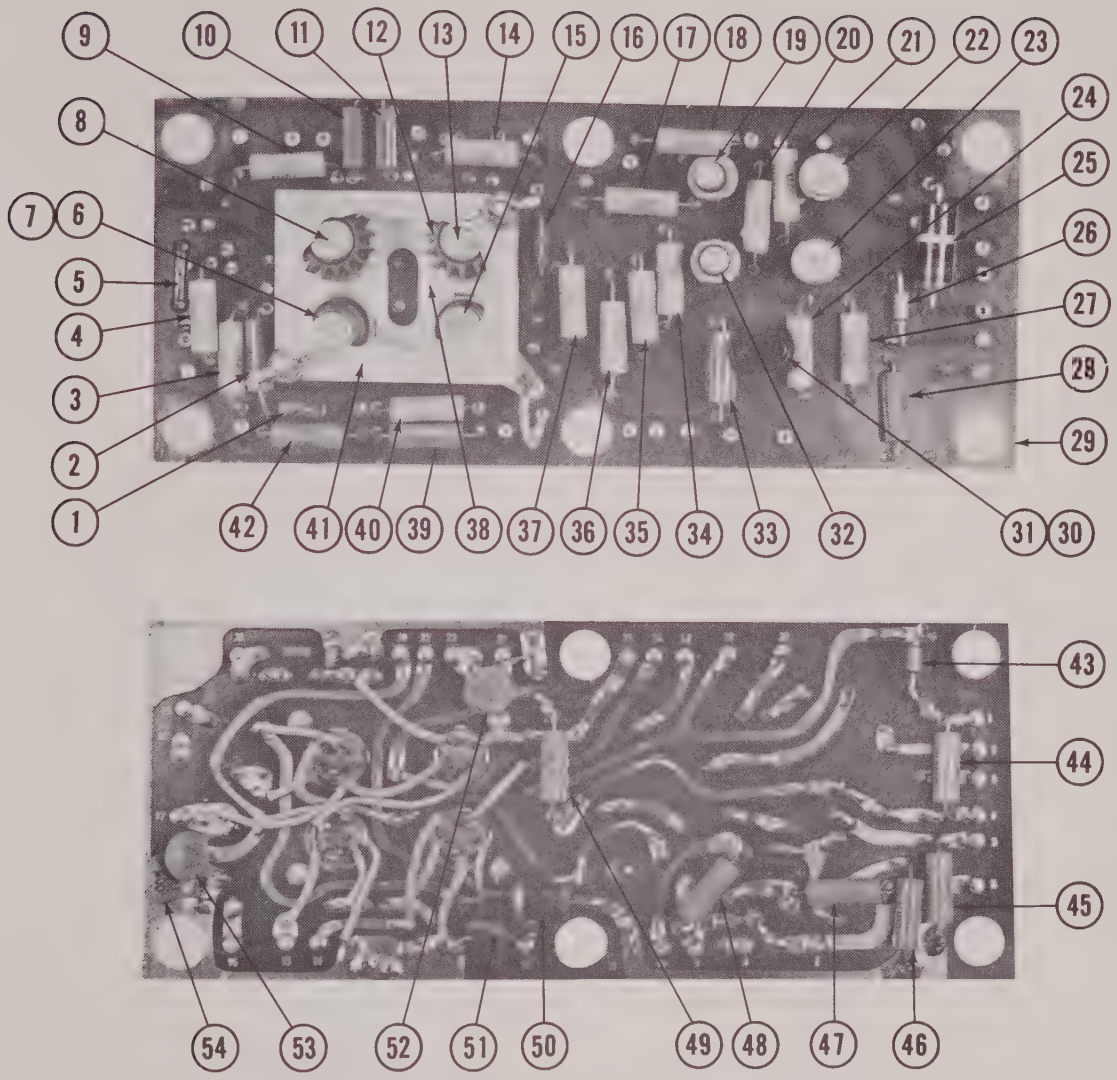


FIGURE 9. CIRCUIT BOARD

FIG. & INDEX NO.	PART NO.	NOMENCLATURE	REF. DESIG.	QTY.	PRICE EACH
9-	2208	PRINTED CIRCUIT BOARD ASSEMBLY			75.00
-1	BB6-5	CAPACITOR, CERAMIC .001 uf 600V	C7	1	.25
-2	BI2-31	RESISTOR, 4.02 MEG 1/4W 1%	R24	1	1.50
-3	BI2-15	RESISTOR, 221K 1/4W 1%	R23	1	.85
-4	BI2-64	RESISTOR, 68.1K 1/4 W 1%	R44	1	.75
-5	BI2-2	RESISTOR, 33.2K 1/4 W 1%	R15	1	.85
-6	BN1-22	NUVISTOR SOCKET		4	.35
-7*	BL1-43	TUBE, ELECTRON 6CW4 NUVISTOR	V4	1	4.50
-8*	BL1-43	TUBE, ELECTRON 6CW4 NUVISTOR	V1	1	4.50
-9	BI2-22	RESISTOR, 51.1K 1/4 W 1%	R11	1	.85
-10	BB1-10	CAPACITOR, MICA 100 uuf 500 V	C1	1	1.00
-11	BB1-10	CAPACITOR, MICA 100 uuf 500 V	C2	1	1.00
-12*	BL7-1	HEAT SINK		2	1.00
-13*	BL1-43	TUBE, ELECTRON 6CW4 NUVISTOR	V2	1	4.50
-14	BI2-22	RESISTOR, 51.1K 1/4W 1%	R12	1	.85

*NOT PART OF 2208 ASSEMBLY

FIG. & INDEX NO.	PART NO.	NOMENCLATURE	REF. DESIG.	QTY.	PRICE EACH
9-15*	BL1-43	TUBE, ELECTRON 6CW4 NUVISTOR	V3	1	4.50
-16	BI2-2	RESISTOR, 33.2K 1/4W 1%	R16	1	.85
-17	BI2-37	RESISTOR, 332 Ohm 1/4W 1%	R31	1	1.50
-18	BI2-38	RESISTOR, 2.55K 1/4W 1%	R34	1	1.00
-19*	BL4-9	TRANSISTOR, 2N109	Q 3	1	4.50
-20	BI2-18	RESISTOR, 1.21K 1/4W 1%	R35	1	1.00
-21	BI2-76	RESISTOR, 402 Ohm 1/4W 1%	R36	1	.75
-22*	BL4-20	TRANSISTOR, 2N388	Q 5	1	2.00
-23*	BL4-20	TRANSISTOR, 2N388	Q 4	1	2.00
-24	BI2-18	RESISTOR, 1.21K 1/4W 1%	R18	1	1.00
-25	BI4-3	RESISTOR, 15 Ohm 2W	R42	1	.35
-26	BL3-4	DIODE, ZD91A	CR3	1	5.50
-27	BI2-10	RESISTOR, 3.32K 1/4W 1%	R17	1	1.00
-28	BI2-44	RESISTOR, 100K 1/4W 1%	R51	1	.75
-29	22309	PRINTED CIRCUIT BOARD		1	27.50
-30	BN1-21	TRANSISTOR SOCKETS		5	.75
-31*	BL4-1	TRANSISTOR, 2N292	Q1	1	5.50
-32*	BL4-9	TRANSISTOR, 2N109	Q 2	1	4.50
-33	BI2-44	RESISTOR, 100K 1/4W 1%	R19	1	.75
-34	BI2-23	RESISTOR, 10K 1/4W 1%	R27	1	.85
-35	BI2-37	RESISTOR, 332 Ohm 1/4W 1%	R30	1	1.50
-36	BI2-37	RESISTOR, 332 Ohm 1/4W 1%	R28	1	1.50
-37	BI2-23	RESISTOR, 10K 1/4 1%	R26	1	.85
-38	21761	NUVISTOR PLATE		1	.50
-39	BI2-31	RESISTOR, 4.02 MEG 1/4W 1%	R21	1	1.50
-40	BI2-15	RESISTOR, 221K 1/4W 1%	R20	1	.85
-41*	22302	HEAT SINK PLATE		1	.25
-42	BI2-31	RESISTOR, 4.02 MEG 1/4W 1%	R22	1	1.50
-43	BL3-4	DIODE ZD91A	CR4	1	5.50
-44	BI2-3	RESISTOR, 47K 1/4W 1%	R50	1	1.00
-45	BI2-33	RESISTOR, 2.21K 1/4W 1%	R39	1	1.00
-46	BI2-33	RESISTOR, 2.21K 1/4W 1%	R40	1	1.00
-47	BI2-18	RESISTOR, 1.21K 1/4W 1%	R37	1	1.00
-48	BI2-27	RESISTOR, 47.5 Ohm 1/4W 1%	R32	1	1.25
-49	BI2-64	RESISTOR, 68.1K 1/4W 1%	R43	1	.75
-50	BI4-3	RESISTOR, 15 Ohm 2W	R49	1	.35
-51	BB6-12	CAPACITOR, .005 uf	C4	1	.50
-52	BB6-12	CAPACITOR, .005 uf	C5	1	.50
-53	BB6-12	CAPACITOR, .005 uf	C8	1	.50
-54	BB6-12	CAPACITOR, .005 uf	C9	1	.50

*NOT PART OF 2208 ASSEMBLY

CROSS REFERENCE CHART

Wiring Diagram-Parts List

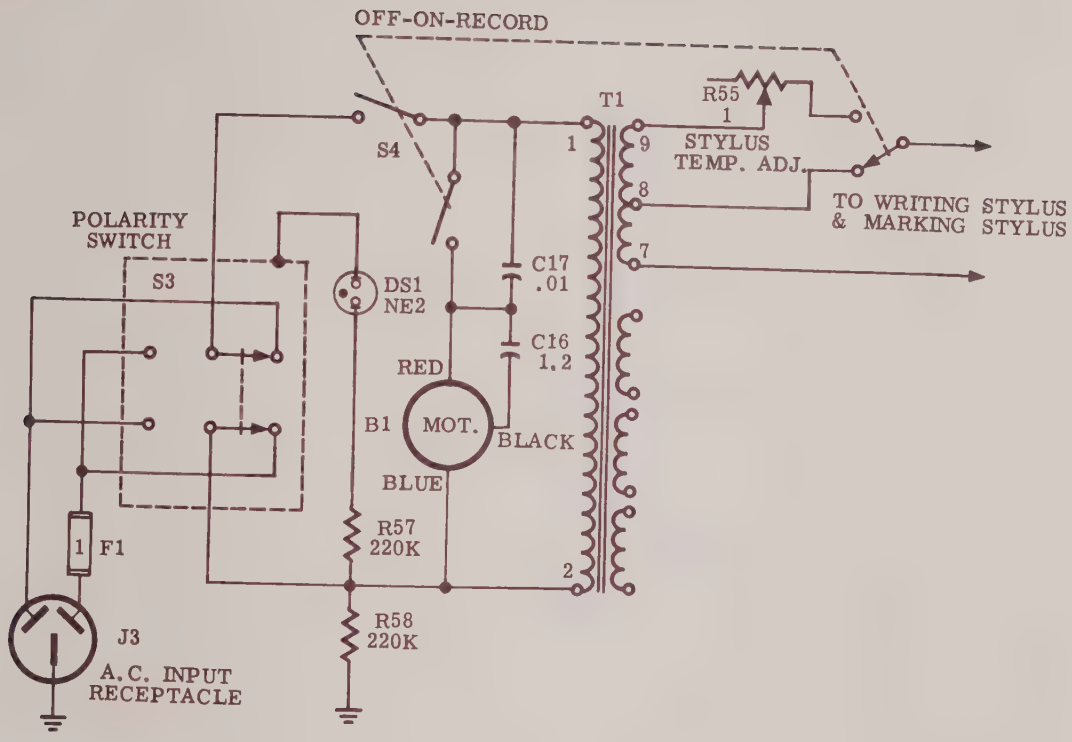
SYM.	BIRTCHER PART NO.	FIG. & INDEX NO.
B1*	BQ-12	6-1
B1*	BQ-13	6-1
B1**	BQ-21	6-1
B1**	BQ-22	6-1
BT1	BA2-2	5-17.9
C1	BB1-10	9-10
C2	BB1-10	9-11
C3	BB9-9	8-12
C4	BB6-12	9-51
C5	BB6-12	9-52
C6	BB9-9	8-12
C7	BB6-5	9-1
C8	BB6-12	9-53
C9	BB6-12	9-54
C10	BB10-9	7-5
C11	BB10-7	8-5
C12	BB8-22	6-5
C13	BB8-10	8-26
C14	BB8-25	6-4
C15	BB8-31	8-20
C16**	BB12-1	8-3
C17	BB6-8	7-3
C18**	BB6-8	7-3
CR1	BL2-13	8-17
CR2	BL2-13	8-18
CR3	BL3-4	9-26
CR4	BL3-4	9-43
CR5	BL2-13	8-14
CR6	BL2-13	8-14
CR7	BL2-13	8-14
CR8	BL2-13	8-14
DS1	BF3-2	5-4
DS2	BF1-2	5-16
DS3	BF1-2	5-11
DS4	BF1-9	5-2
F1	BS1-2	5-6
F1***	BS1-10	5-6
G1	1941	5-23
J1	BM3-6	7-2
J2	BM3-6	7-1
J3	BU10-8	5-17.10
J4	BU1-7	5-17.16

SYM.	BIRTCHER PART NO.	FIG. & INDEX NO.
K1	(*)BJ1-9	6-3
Q1	BL4-1	9-31
Q2	BL4-9	9-32
Q3	BL4-9	9-19
Q4	BL4-20	9-23
Q5	BL4-20	9-22
Q6	BL4-11	8-10
Q7	BL4-11	8-9
Q8	BL4-28	8-19
Q9	BL4-11	8-8
R1	BI2-55	5-17.11
R2	BI2-55	5-17.11
R3	BI2-40	5-17.12
R4	BI2-23	5-17.13
R5	BI2-23	5-17.13
R6	BI2-23	5-17.13
R7	BI2-55	5-17.11
R8	BI1-146	5-17.14
R9	BI1-146	5-17.14
R10	BI2-35	5-17.7
R11	BI2-22	9-9
R12	BI2-22	9-14
R13	BI2-36	5-17.8
R14	BI6-25	8-7
R15	BI2-2	9-5
R16	BI2-2	9-16
R17	BI2-10	9-27
R18	BI2-18	9-24
R19	BI2-44	9-33
R20	BI2-15	9-40
R21	BI2-31	9-39
R22	BI2-31	9-42
R23	BI2-15	9-3
R24	BI2-31	9-2
R25	BI6-39	8-4
R26	BI2-23	9-37
R27	BI2-23	9-34
R28	BI2-37	9-36
R29	BI6-27	6-7
R30	BI2-37	9-35
R31	BI2-37	9-17
R32	BI2-27	9-48

SYM.	BIRTCHER PART NO.	FIG. & INDEX NO.
R33	BI6-28	6-8
R34	BI2-38	9-18
R35	BI2-18	9-20
R36	BI2-76	9-21
R37	BI2-18	9-47
R38	BI6-40	8-6
R39	BI2-33	9-45
R40	BI2-33	9-46
R41	BI6-40	8-6
R42	BI4-3	9-25
R43	BI2-64	9-49
R44	BI2-64	9-4
R45	BI2-2	7-6
R46	BI2-2	7-4
R47	BI3-22	8-23
R48	BI2-5	8-22
R49	BI4-3	9-50
R50	BI2-3	9-44
R51	BI2-44	9-28
R52	BI4-12	8-24
R53	BI2-65	8-25
R54	BI3-9	8-21
R55	BI6-7	6-6
R56	BI5-4	8-13
R57	BI1-80	6-10
R58	BI1-69	6-11
R59	BI2-2	5-17.15
S1	2207	5-17.1
S2	BK7-2	5-18
S3	BK1-7	5-8
S4**	BK3-22	5-14
S4*	BK3-6	5-14
T1	BR1-16A	8-2
T1***	BR5-16A	8-2
TB1	2199	6-9
TB2***	1802-4	8-1
V1	BL1-43	9-8
V2	BL1-43	9-13
V3	BL1-43	9-15
V4	BL1-43	9-7
V5	BL1-52	6-2

* 335-1 only
** 335-2 only
*** 335-1 & 335-2 Export only

(*) K1 BJ1-18 Replaces BJ1-9



Model 335-1 (Single speed) Motor & Power Circuit Schematic Diagram

PRIOR TO SERIAL NUMBER AU84D-2670, B1 MOTORS WERE WIRED FOR COUNTERCLOCKWISE ROTATION WHEN VIEWED FROM SHAFT END. THEY ARE NOW WIRED FOR CLOCKWISE ROTATION.

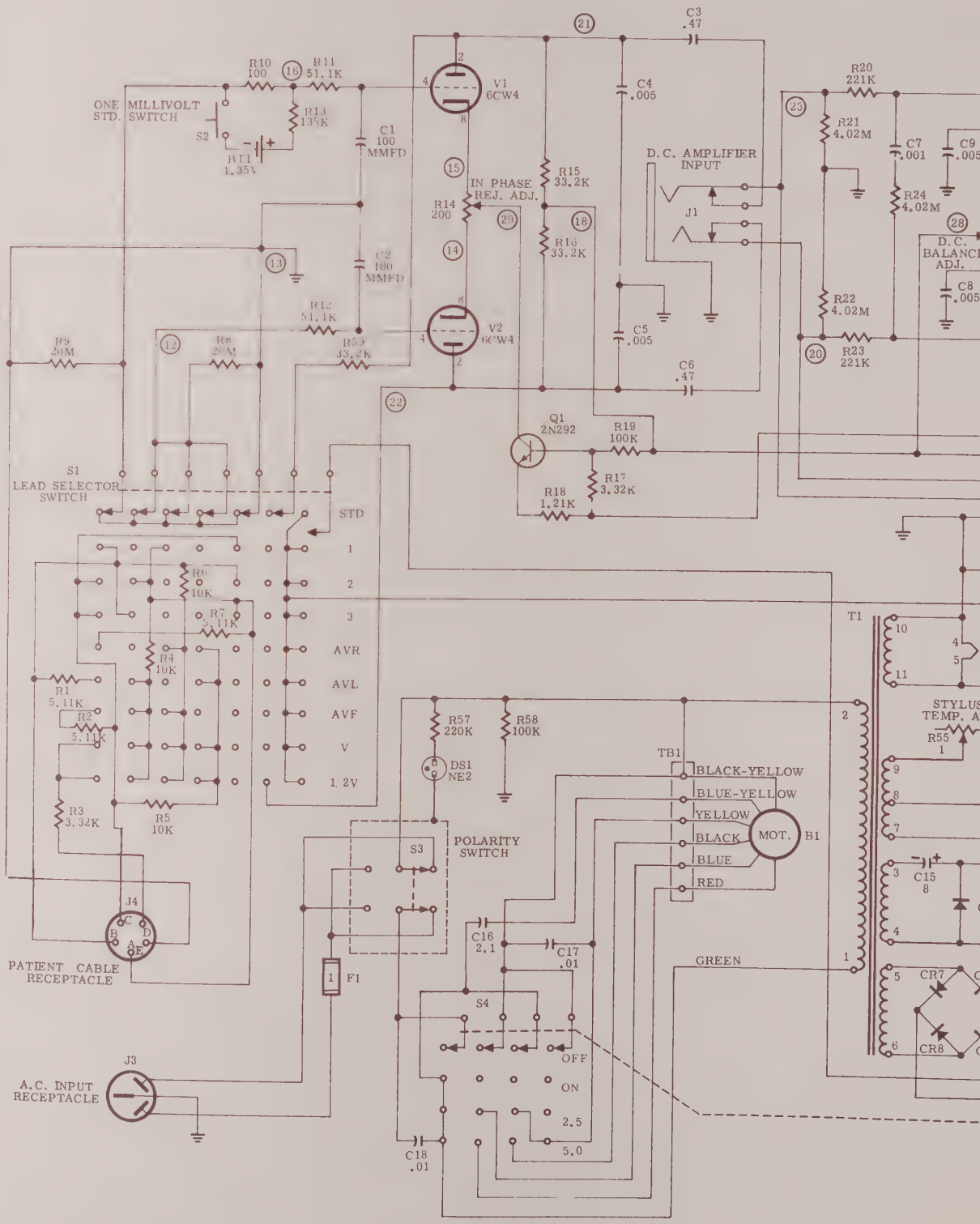
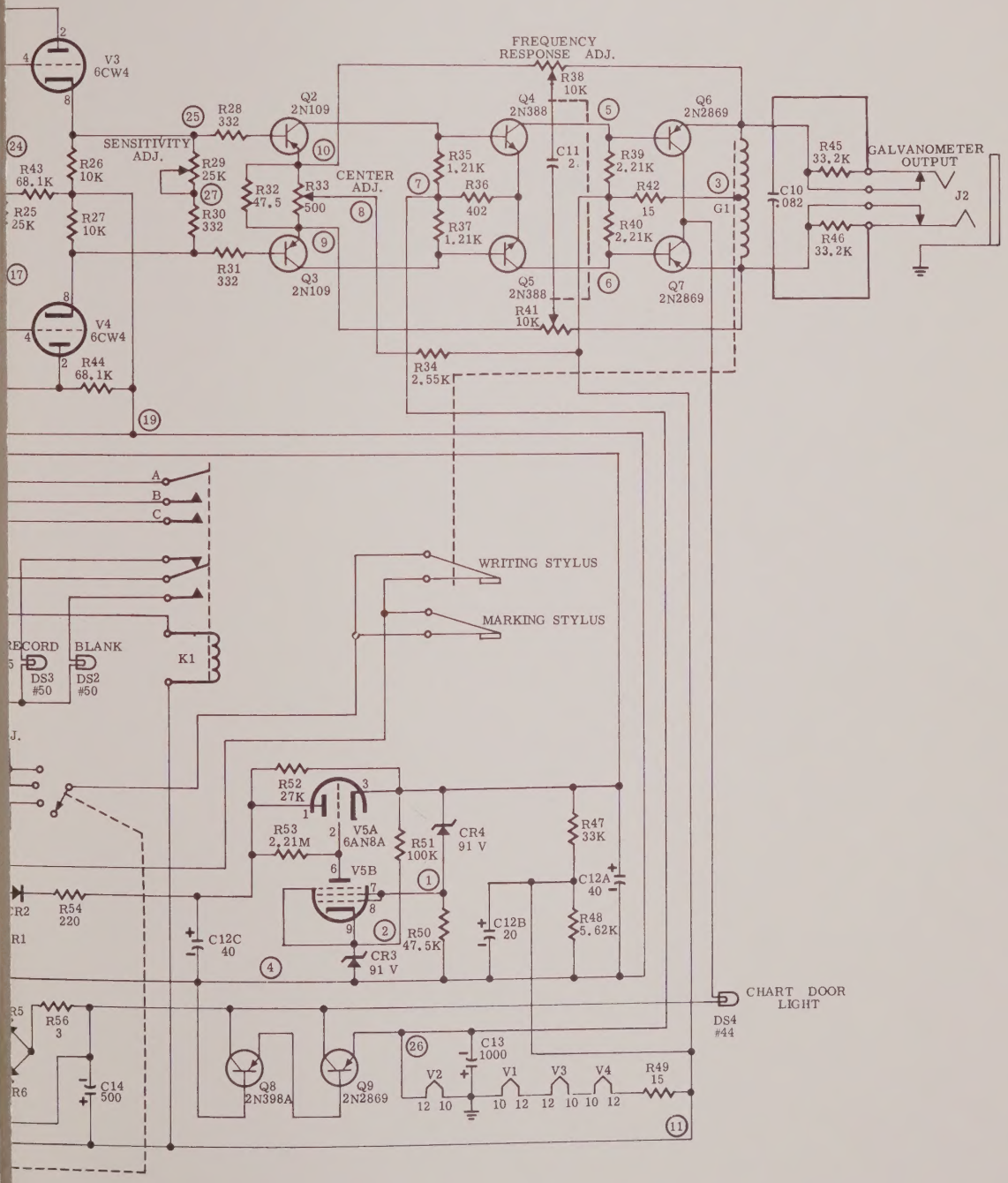


Figure 10. 335-2 (Dual speed) Sch



NOTE: 1. Unless otherwise specified, all resistances are in ohms. All capacitances are in microfarads.
2. ◯ Denotes connection to circuit board.
3. Canadian Standards Association approved units, the polarity switch S3, light DS1, resistor R57 & resistor R58 are omitted.